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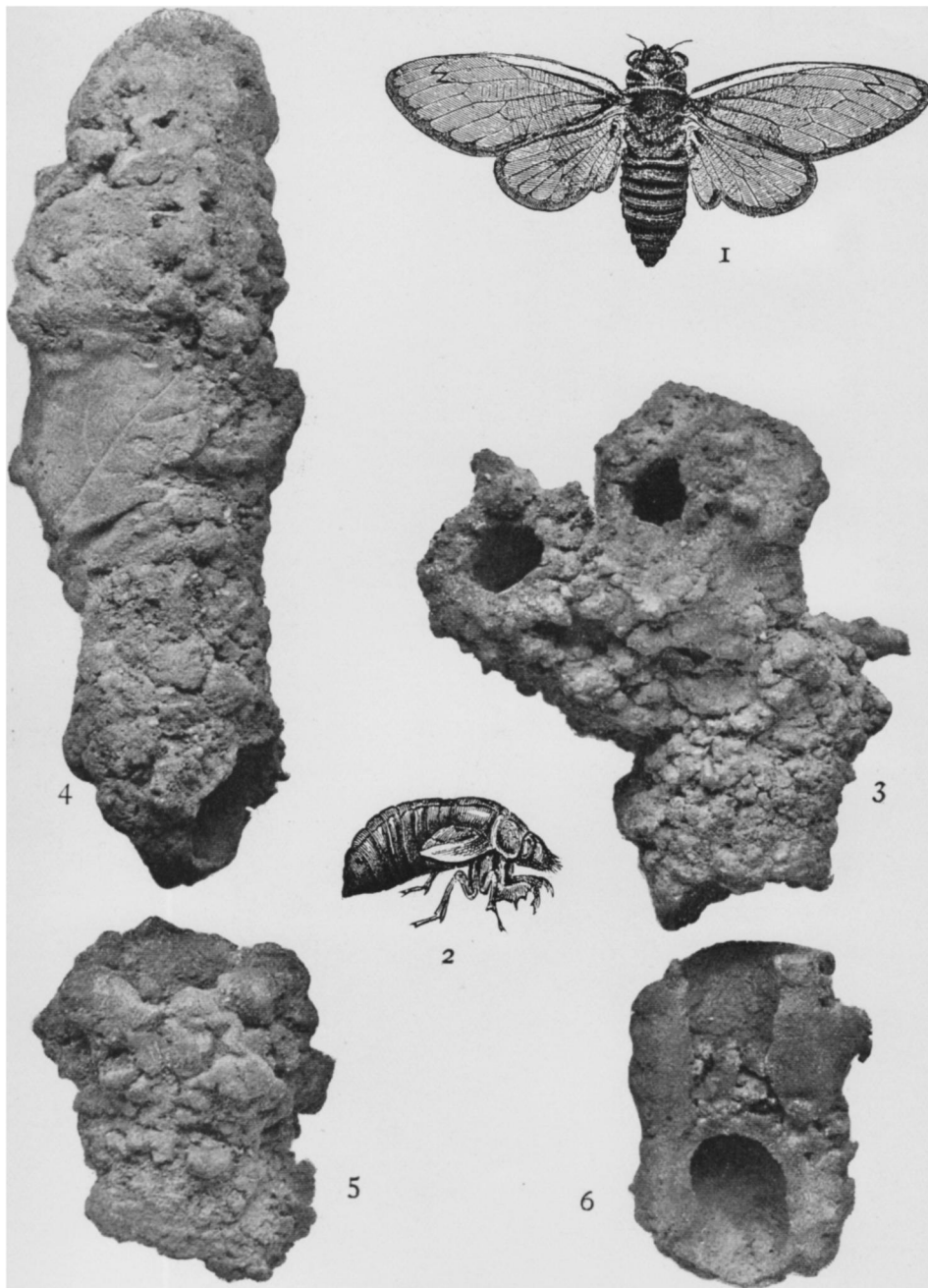
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Domes of *Cicada septendecim*.

DOMED BURROWS OF CICADA SEPTENDECIM.

By BENJAMIN LANDER.

In 1877 a remarkable phenomenon connected with the advent of the periodical Cicada -- the so-called seventeen-year "locust", (Fig. 1) was observed at Rahway, N. J. — On opening a cellar which had been closed up to the time that the pupæ (Fig. 2) issued from the ground, the floor was found to be studded with small, hollow, cone-like structures, built of mud, which had been constructed as extensions of Cicada burrows. The attention of Professor J. S. Newberry having been called to the circumstance he deemed it of such importance that he secured specimens, and obtained a detailed statement of the features of the case, signed by several leading citizens of Rahway, and published the account in the School of Mines Quarterly of Columbia College, Jan. 1886; and in a separate illustrated pamphlet. As the Professor made no mention of ever having seen like structures before, the inference is natural that he had not.* Indeed, so rare were they prior to the advent of the same brood in 1894, that few entomologists had seen them, and no accurate description existed. Last year, countless numbers of these hut-like domes were observed at various places.

On the fourth of May 1894, while in the woods on the summit of South Mountain, at Nyack, N. Y., I came upon a spot that had recently been burnt over. On this area I observed vast quantities of the Cicada structures, entirely closed, averaging about two and a half inches in height; the aggregation ending at the very edge of the burnt section. So thickly studded was the ground that often eight or ten would be found in the space of a square foot; in one case I counted twenty-three in such a space. Subsequent explorations showed that the Cicada city extended over an area of not less than sixty acres. Eight large aggregations were discovered by me on top of the Nyack hills and the Palisades, covering many acres, and one near a stone quarry at a lower elevation; none of them in a place subject to overflow. Later, when only the ruins of the domes remained, I visited two areas where large numbers had been found; one in ground thinly covering massive sandstone, and another hard by a quarry, where the top soil was thin. An account of the discovery was published in The New York Times, and in the Scientific American of Oct. 16th. I offered

* Previously described and figured by Walsh and Riley (see Am. Ent., Vol. I, 1868, p. 65).
Wm. B.

an attempt at an explanation of the mystery; a criticism of my theory appeared in the issue of Nov. 10th, and my reply in that of Nov. 27th; to all of which the reader is referred.

Hitherto it has been supposed that the object of these domed extensions was to protect the burrows from overflow of water, and that when found on high ground they had been built by pupæ that had inherited the instinct from ancestors that had lived in "low, wet places". But this theory has been completely overthrown by the fact that millions of domed burrows were found on the summits of lofty elevations, not "subject to overflow", at Nyack, and many other places visited, and none of the vast army of builders chose "low, wet places"; notwithstanding that the lower levels swarmed with the insects, the ground in many places having been honey-combed with their open burrows. One salient fact is worth a volume of generalizations; but further proof that the theory is untenable will be offered hereinafter.

The explanation I have advanced as to the cause of the interesting phenomenon is based on the fact that in order to be revived so much in advance of pupæ which later emerged from open burrows, the dome-builders must have been near enough to the surface to feel the vivifying effects of abnormal, unseasonable warmth. Of course it must be remembered that our sensation of warmth is to degree and that of the insects are two entirely different things.

In the Rahway case the features of abnormally high temperature (compared to that outside,) and shallow burrows are self-evident. The excavation had reduced the depth of the pupæ from the surface. The heat of the sun on the exterior of the enclosure would reach the chamber by conduction and be stored up; making the temperature practically the same night and day, since the warmth could not be carried off by radiation. Thus we often see vegetables sprouting in cellars in the depth of a cold winter. It is altogether logical to suppose that sufficient warmth would obtain to reach the pupæ in their artificially shortened burrows and revive them. Having opened their shafts while undeveloped their reason impelled them to close the orifices, perhaps in an attempt to lessen the too rapidly developing warmth, and as a protection against mice and other vermin. The tubular form of the roof showing the "persistence of habit"; their seventeen-year underground work having been of that nature. The normal temperature out-

side, and the radiation carried off by the breeze, prevented an early revival of the unsheltered pupæ; which at their proper season emerged from open shafts.

A somewhat similar case is where domed burrows were observed near Washington at a former advent, in a thick pine grove. Here, the protection from the wind by the deep, overhanging curtains of the evergreens, would prevent, in a measure, a too rapid waste of the diffused warmth; while the constant radiation by night of absorbed heat stored up by day among the thick foliage would tend to offset the loss from the ground; rendering the temperature like that in the cellar, practically the same, day and night; doubtless raising it enough over that in the exposed places outside (where the wind would act as a fan,) to supply sufficient warmth to revive the pupæ: it may be only a week or two before those not thus protected. This, of course, is assuming that the domed burrows were shallow — the pupæ nearer the surface than those outside, which might have been the case for one or more of several reasons: the insects might not have burrowed much or any below their root-supplies, from which they obtain subsistence, or from other causes which will be referred to later.

If this theory of unusual warmth and shallow burrows is to hold, the temperature at the time the millions of domes were built on the Nyack hills and the Palisades must have been far above normal, and the localities must have had features that would prevent deep burrowing. It is susceptible of proof that these conditions existed. March of 1894 was unusually warm: the hottest March on the records of the New York weather Station, extending to 1870, and was 223 degrees in excess of normal. At Nyack it was even warmer, as shown by published records. Wild flowers blossomed a month ahead of their season. Even as far up as Poughkeepsie, where domed burrows were found, the recorded temperature was practically the same as at New York. A large part of the dome areas had been burnt over early in March. In these places the combined natural and accidental heat no doubt brought the pupæ speedily to the surface. Even where the leaves and underbrush had been burnt off the preceding Fall the heat of the sun would sooner penetrate the bare ground.

The Nyack hills and the Palisades are composed of massive rock; their summits ground off by glacial action. These heights are thinly covered with earth; the extreme elevations, more or

less level, are, naturally, less covered than elsewhere. It was in such places that the domes abounded; those found over quarries and elsewhere, previously alluded to, were, like those in higher areas, personally examined by me, and all were found to be in shallow earth. This feature furnishes the second condition of the theory; the first is a matter of indisputable record.

Among the places where domed burrows were found in thin soil were Nyack; Upper Nyack; South Nyack; Grandview and Piermont; and on top of the Palisades near Alpine; Closter; Demarest; Cresskill; Englewood; New Durham and Fort Lee. Several of these areas had been burnt over.

A correspondent writes me that in a dome area observed by him the structures were built after a fire, as shown by their containing burnt twigs. But this is just what would occur after a fire: The builders would come in contact with them in their work and they would be incorporated. I have many such specimens. A professional entomologist who visited the same spot writes that the case I reported from Nyack to the New York Times (wherein it was stated that the ground had been burnt over before the domes were built,) so fitted to the one observed by him that he was inclined to think it was an account of the one he had seen, and that the name of the locality had in some way been changed. It is not claimed that fire is necessary to revive the pupæ; but it is evident that in some cases it has been effectual; in others the abnormal heat of the sun was sufficient.

Professor John B. Smith reports that the structures were found near a quarry at Newark, N. J., and at Port Jefferson, in the same state. In the latter case vast numbers were observed by Dr. J. Howard Willets who possesses substantial proof that they were built five or six days after a forest fire; the domes close together, and ending abruptly at the edge of the burnt area.

It is not claimed that all the dome aggregations were in soil over rocks. The burrows might have been shallow from a variety of causes. In one case reported there was a sub-stratum of coarse sand, too incoherent for burrowing. In other places the sub-soil might have been wet, peaty, or gravelly. Even in deep soil some pupæ would be nearer the surface than others, and if near enough to be prematurely revived by the heat would erect their protective domes; among which the open burrows of the deeper pupæ would

later appear. Exactly such a case — open burrows among the domes, has been reported to me by a well known entomologist.

A unique illustration of the protective function of the dome is shown in a circumstance which occurred during a former advent of the Cicadas. A scientist and writer on entomology informs me that some laborers in cutting through a bank laid open the burrow of a pupa: Soon after, "upon the fresh, vertical cutting there appeared one of these 'huts' rising from the opening". Here was a *shallow burrow* (artificially so.) *prematurely opened*; the *undeveloped pupa* erecting a shield against the vicissitudes of external temperature; which would also serve as a protection against outside enemies: a perfectly logical analogism.

Perhaps enough substantiating facts have been adduced, but two features of the cases observed by me are so significant that they lend extreme probability to the explanation I offer, and certainly disprove the heredity theory. First: No open holes occurred in the areas over the smooth glacial-worn rocks — there the soil was almost uniformly shallow; and it is beyond belief that what few "low ground" builders in the past that might have stolen horse-back rides to the mountain tops and the lofty Palisades, should have chosen just such prescribed places, and have utterly annihilated the open burrow builders — native to the soil. Second: A wide and deep gully (of course subject to overflow,) in the area of the largest Cicada city had no domed burrows, as there the earth was deep, from the alluvial deposits of ages, but later, when the great swarm arrived, this hollow was found to be honey-combed with open holes.

In conclusion, with reference to the causes and purposes of the domes, in view of what has been adduced it seems altogether likely that every one, no matter when or where observed, was erected by an undeveloped pupa that had prematurely opened its burrow from near the surface, and closed it as a protection while awaiting maturity.

Previous accounts erroneously state that these heretofore rare objects have an orifice at the surface of the ground. When the time for moulting arrives a hole is clawed through the roof (Fig. 3). A unique specimen in my collection shows the cast-off shell of a pupa firmly fixed in the opening: the hole had been made too small for entire emergence, but the little fellow had been able to escape from his horny armor. Many specimens show clear im-

pressions of leaves (Fig. 4); proving that the fine clay or forest mould, worked with a cement exuded by the insect, was quite plastic. It would seem that the thin claws of the pupa were too inadequate for carrying very soft material. It may be that the little miner and mason is his own hod-carrier; conveying his load of plaster to the walls of his building on his head: a conjecture that would seem fanciful indeed were it not for the fact that the intelligent creature when burrowing downward, does what amounts to practically the same thing. Having displaced a pellet he cleverly places it on his head, and by a turn of his body carries the pellet to the earth above and presses it in.

From personal observations I am inclined to think that the structures are built at night; the builders beginning work at twilight, for the same reason that they choose that time to emerge from their burrows to moult; as the absence of the sun's heat in one case would prevent the exuding cement from drying, and keep the rim of the dome moist for cohesion; in the other the wings would not dry too rapidly for full expansion. Hoping that I might see the pupæ at work I broke off the tops of several domes, but after long watching observed no attempt at repairs. All but two or three were finally roofed over, but on the inside, considerably below the rim (Fig. 5); probably on account of being damper there, or that the pupæ could more readily prepare the inner wall for the masonry by smearing it with the adhesive cement. Among the multitude of domes a few were found that had been left unfinished. Doubtless the builders had been captured by crows, or other foragers. They afford an interesting illustration of the manner of placing the pellets on the rim. (Fig. 6.)

The scope of this article is confined to a record of observations and analyses of salient facts. Much that might be considered of interest to entomologists must remain unwritten for want of space. But I trust some light has been thrown on what has been considered one of most marvelous of the phenomena connected with insect life. If the explanation offered is the true one, it would seem to render still more diaphanous the supposititious veil between "instinct" and reason, and emphasize our impressions of the long pathway that has been trodden by our little friends and predecessors.